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From an Automated Flight-Test Management System to a Flight-Test Engineer's Workstation

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1 SUMMARY

This paper describes the capabilities and evolution of a flight-test engineer's workstation (called TEST_PLAN) from an automated flight-test management system. The concept and capabilities of the automated flight-test management system are explored and discussed to illustrate the value of advanced system prototyping and evolutionary software development.

2 NOMENCLATURE

ART	automated reasoning tool
ATMS	automated flight-test management system
dof	degree of freedom
FTE	flight-test engineer
FTTC	flight-test trajectory controller
FTTG	flight-test trajectory guidance
GUI	graphical user interface
HARV	High Alpha Research Vehicle
RDBMS	relational database management system
TACT	tactical aircraft technology

3 INTRODUCTION

This paper describes the development and capabilities of a flight-test engineer's workstation called TEST_PLAN and its evolution from the automated flight-test management system (ATMS). The ATMS was a tool for flight-test planning and scheduling; it contained expert systems for maneuver ordering, range management, and maneuver requirements evaluation. These expert systems were combined with three and six-degree-of-freedom simulations, state-of-the-art trajectory optimization, and a powerful graphic user interface to provide a desk top workstation.

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TEST_PLAN is a computer program designed to run on standard graphics workstations as an aid to flight-test engineers (FTEs) in planning and executing flight-test programs. TEST_PLAN allows the FTE to organize and file extensive amounts of planning data while satisfying planning requirements on a flight-by-flight basis using aircraft and flight-specific information about instrumentation, telemetry, range, center-of-gravity, airborne and ground support, aerodynamic configuration, system configuration, and payload.

TEST_PLAN is the result of several generations of evolution. Originally combined with a maneuver autopilot, the first version of the ATMS was designed for flight-test maneuver planning and scheduling as well as maneuver execution and real-time flight-test monitoring; this first version of the ATMS was demonstrated in October 1987 using the NASA simulation facility at the Dryden Flight Research Facility. A second workstation version of ATMS evolved from lessons learned from the preliminary version—this second version eliminated the maneuver autopilot concept but retained a real-time flight monitoring capability; version two of the ATMS was demonstrated in mid-1990 at NASA using the F-18 High Alpha Research Vehicle (HARV) flight-test plans. A third commercial version of ATMS (called TEST_PLAN) resulted from the earlier experience and is designed as a FTE aid in planning and executing flight-test programs; TEST_PLAN is currently being used or considered for use by United States and international flight-test organizations.

4 THE AUTOMATED FLIGHT-TEST MANAGEMENT SYSTEM

The ATMS was originally developed at the NASA Dryden Flight Research Facility as a part of the NASA Aircraft Automation Program–a program focused on applying interdisciplinary state-of-the-art technology in artificial intelligence, control theory, and systems methodology to problems of operating and flight testing high-performance aircraft. In this section we present the background and a description of the ATMS [1,2,3].

4.1 Background of the Automated Flight-Test Management System

The ATMS was an outgrowth of the flight-test trajectory guidance (FTTG) work performed over the past decade on such programs as the F-111 Tactical Aircraft Technology (TACT) Program, the F-15 Propulsion/Airframe Integration Program, and the F-15 10°-Cone Program [4]. The FTTG provided display information to the pilot to allow complex, demanding flight research maneuvers to be flown more accurately. The FTTG was extended to a closed-loop system for the Highly Maneuverable Aircraft Technology (HiMAT) Program flight-test maneuver autopilot (FTMAP) [5]. In conjunction with this flight research at Dryden, Integrated Systems, Inc., under contract to NASA has developed a design methodology for these types of controllers [6,7,8] which has resulted in the basis of a flight-test trajectory controller (FTTC) which was flight tested in early 1990 on the F-15 Highly Integrated Digital Electronic Control (HIDEC) aircraft [9]. This FTTC was a major component of the ATMS as originally conceived and implemented.

The ATMS project was structured around a flight-test scenario and was an extension of work performed by SPARTA, Inc., (SPARTA, Inc., Laguna Hills, CA) under contract to NASA defining the need for a National Remote Computational Flight Research Facility (NRCFRF). The work on the NRCFRF contract defined the need for an expanded remotely augmented vehicle (RAV) capability and a flight program to demonstrate that capability. In the ATMS, a range, energy, and flight-test monitor expert system was used in conjunction with the FTTC to order maneuvers by priorities and energy management considerations while restricting the vehicle to the confines of a specified Edwards AFB test range. This expert system could be used online to control the research aircraft in flight and monitor the progress of a flight test; or offline as a planning tool for ordering the test maneuvers for a flight. The expert system used predictions of maneuvers based on simulation models for planning and actual flight-test data measurements for real-time vehicle control, data monitoring and flight test management.

4.2 Components of the Automated Flight-Test Management System

The main components of the ATMS were a trajectory controller based on the FTTC system [7,8], a flight-test planning expert system, a man–machine interface, and a flight-test monitoring expert system. The partitioning of functions in the ATMS was designed with two goals in mind; minimizing the bandwidth of the communication between components, and appropriate distribution of functions between numeric and symbolic processing.

The components described in this section perform the flight planning and monitoring functions. The fully developed ATMS (Fig. 1) was expected to perform program planning, block planning, and in-flight replanning which are not described herein as they were never implemented in the first ATMS.

4.2.1 Trajectory Controller

The trajectory controller was a collection of outer-loop guidance control laws which provide precise control for a

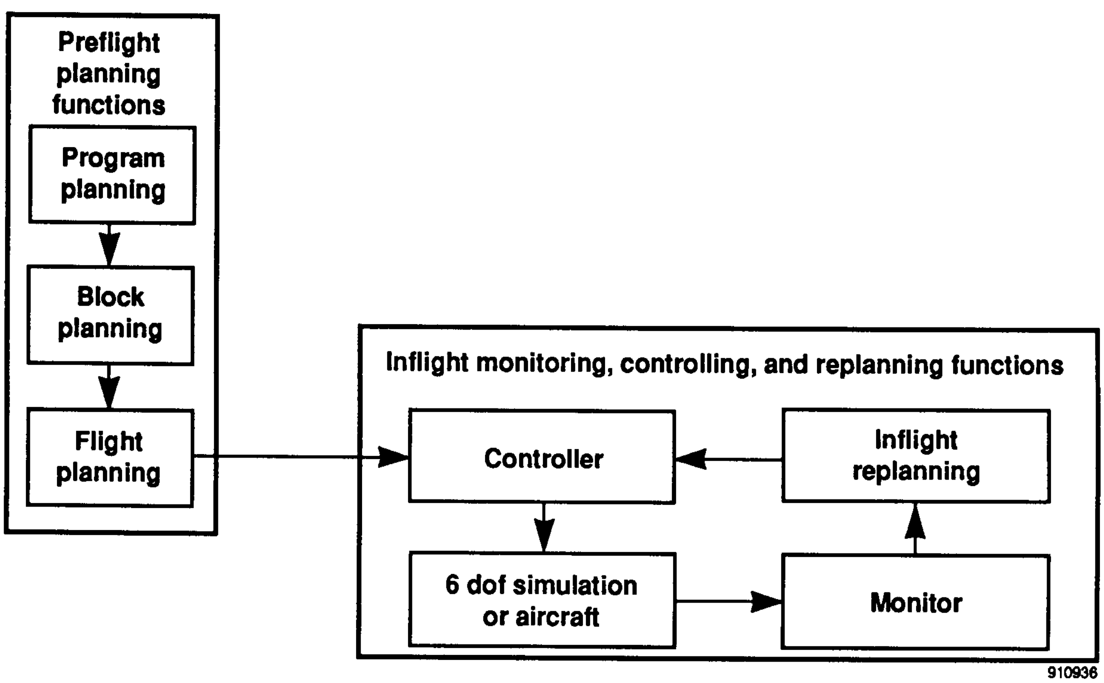

Fig. 1 ATMS functions.

vehicle performing high-quality flight research maneuvers such as level accelerations, wind-up turns, and pushover-pullup maneuvers. The trajectory controller was algorithmic, implemented in FORTRAN 77, and executed on a numeric processor.

The interface between the trajectory controller and the remaining components of the ATMS was designed to minimize the bandwidth of the communications across that interface. The trajectory controller accepted input commands consisting of an ordered list of maneuvers by type. Each maneuver consisted of a trim point, maneuver conditions, and end conditions. These commands contained from three to seven parameters each.

Once maneuver commands were received by the trajectory controller, the controller operated independently of the ATMS until another command list was received. The trajectory controller generated trajectories and trajectory following controls based on the maneuver commands and the aircraft instrumentation.

4.2.2 Flight-Test Planning Expert System

Flight-test planning must be done at several levels. At the highest level, the flights required for an entire program are established by the project requirements. At the next level, blocks of flights are determined by a more detailed analysis of the project requirements and are partitioned according to similarity of prerequisites, flight envelope requirements, and test needs to establish an orderly progression of blocks of flights satisfying the high-level project requirements. Within each block a number of individual flights are identified based on the detailed analysis of maneuvers required to satisfy the block requirements. Individual flights are then identified with a number of these maneuvers and the FTE must order maneuvers within a flight based on considerations of range, fuel, and energy management, as well as maneuver priorities.

The ATMS implemented only the test planner expert system. The test planner accepted a list of maneuvers and ordered them using rules that considered maneuver priorities, energy management, test range boundaries, and envelope limitations. Maneuvers which could not be included in the flight plan were eliminated from the plan being developed.

The flight-test planning expert system accepted test plan inputs from the FTE using a menu driven and icon based man–machine interface or previously stored test plan entries. When the list of test maneuvers was entered into the ATMS, the FTE selected the flight-test planning expert system which then used its knowledge base to order maneuvers, prioritize maneuvers, and construct a trajectory. As each maneuver was added to the planned trajectory, it was tested to insure that no system constraints had been violated. When constraint violations occurred, the flight-test planning expert system displayed information to the FTE describing the constraint violations and provided an explanation of the constraint, if requested. Maneuver priority was extremely important when fuel constraints were tested; lower priority maneuvers were removed from the test plan to satisfy fuel constraints.

The flight-test planning expert system was developed using the Automated Reasoning Tool (ART) expert system development environment hosted on a symbolic computer with a numeric processor board. It contained over 200 rules.

4.2.3 Man–Machine Interface

The man–machine interface component of the ATMS provided a means of information entry and display. This interface was used during flight planning and flight plan execution. The main display had three major components: the map, timeline, and command menu. In the map section of the main display were two types of displays: the trajectory planning display (Fig. 2), and the trajectory map display (Fig. 3). These map displays presented a two-dimensional view of the test range with the aircraft trajectory superimposed. The stored map was larger than the portion presented on the display. Pan and scroll were accomplished by using the mouse to choose an appropriate button depicted across the top of the display. A "navigate" button was also included to quickly determine course and distance between present aircraft position and any point within the stored map. The timeline component of the main display presented information on the aircraft trajectory in terms of altitude as a function of time or events. Figure 4 shows a timeline display of altitude as a function of time. Timeline scroll buttons allowed the FTE to examine different time or event segments by scrolling the timeline. The command menu portion of the main display allowed the user to select (using "mouse" or keyboard inputs) ATMS operational modes, maneuvers, or explanations of ATMS actions.

The man–machine interface was rule based with over 200 rules and presented on the computer monitor and keyboard. The interface was developed in ART.

4.2.4 Flight-Test Monitor Expert System

The flight-test monitor expert system provided an interface between the FTE and either the planned trajectory or the actual trajectory (whether generated by simulation or flight). This system also provided the trajectory controller with inputs from the list of maneuvers in the planned trajectory.

The flight-test monitor expert system issued maneuver requests to the trajectory controller, then monitored the aircraft parameters of interest to insure that no system constraints were violated. This system also monitored maneuver quality. When a system constraint was violated or the quality of a maneuver was unacceptable, the flight-test monitor expert system notified the FTE of the problem and made recommendations based on the information within its knowledge base. Each maneuver was selected from the list of planned maneuvers in order; the flight-test monitor

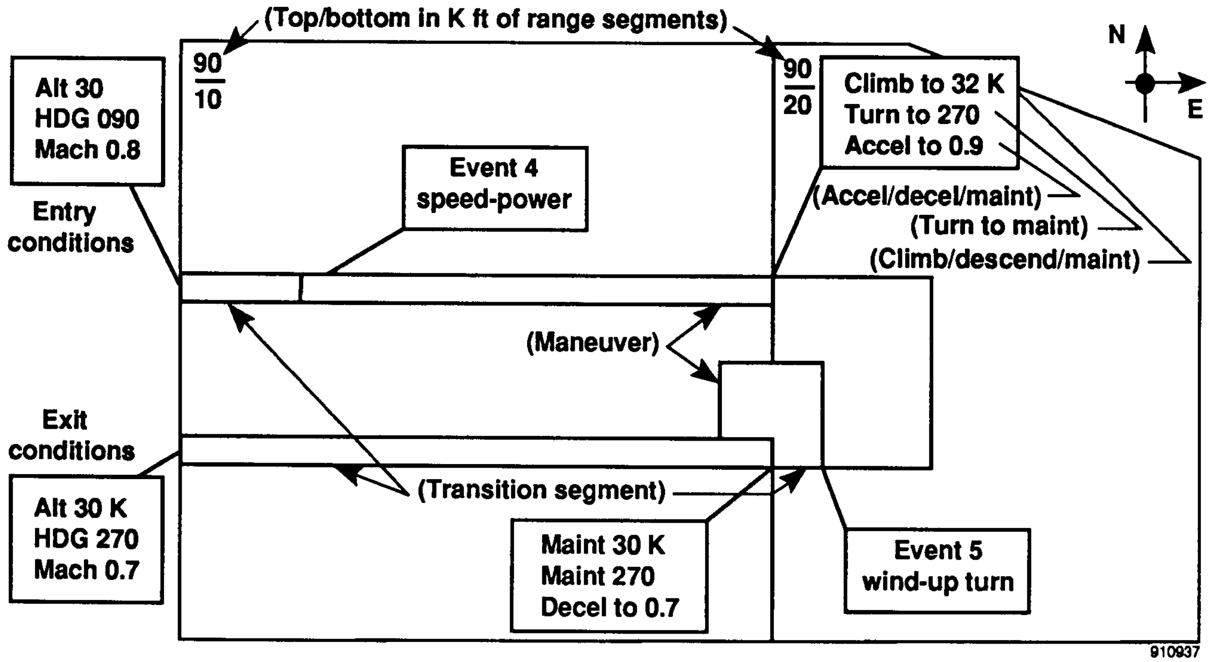

Fig. 2 Trajectory planning display.

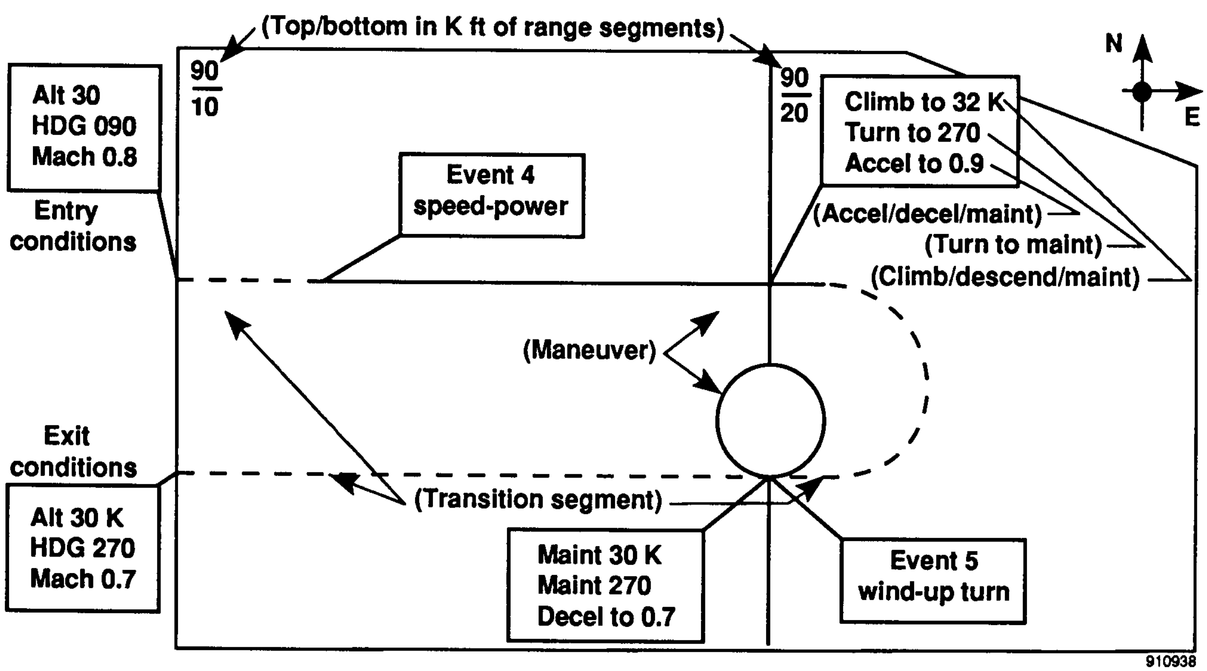

Fig. 3 Trajectory map display.

expert system initiated these maneuvers and then waited for the trajectory controller to finish a maneuver before proceeding to the next maneuver on the list.

4.3 Automated Flight-Test Management System Configurations

The ATMS had three configurations: the FTE workstation, the simulation validation system, and the flight system. The FTE workstation and the simulation validation system were used to develop and evaluate flight-test plans. The simulation validation system was also used to aid in the validation of the flight system including aircraft modifications. The flight system was used to actually conduct flight test by executing the flight-test plan, monitoring the performance of the aircraft, and controlling the aircraft in flight.

4.3.1 Flight-Test Engineer's Workstation

The configurations of the FTE workstation is shown in Figure 5. This system was used by the FTE to develop

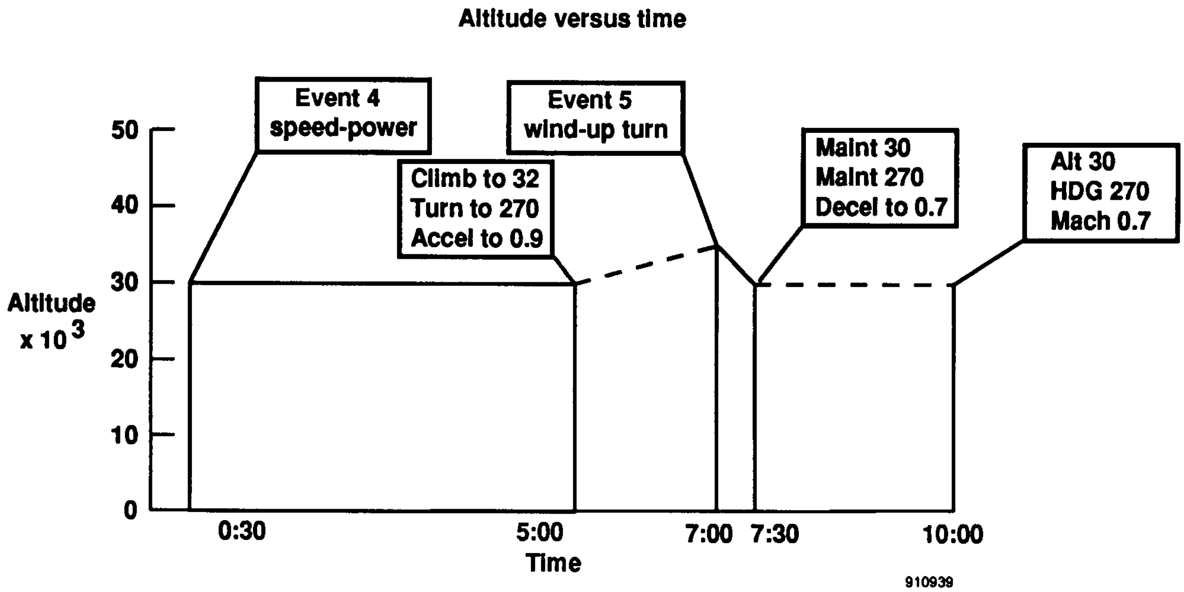

Fig. 4 Timeline display.

preliminary flight-test plans without having to use the aircraft simulator. This provided the FTE with a stand-alone system that was separated from the aircraft simulator, which was always in great demand, and thus allowed more flexibility in test plan development.

The FTE workstation included two computers; a symbolic computer with a numeric processor board and a graphics workstation. The LISP processor on the computer contained the flight-test planning expert system, the man–machine interface system, and the rule-based portion of the flight-test monitoring expert system. The numeric processor on the symbolic computer contained a three degree-of-freedom (3 dof) digital performance simulation (DPS) and the software to execute the algorithmic, trajectory management portion of the flight-test management expert system. The LISP processor and numeric processor board communicated using an internal bus. The graphics workstation contained a six degree-of-freedom (6 dof) simulation of the aircraft and the FTTC. The two computers communicated using Ethernet with a standard protocol.

4.3.2 Simulation Validation System

The configuration of the simulation validation system is shown in Figure 6. This system was used by the FTE to evaluate flight plans developed on the FTE workstation to provide detailed pilot-in-the-loop mission briefing and familiarization, and as a validation facility for testing the ATMS as well as the ground and aircraft systems to be used in the actual flight testing.

The simulation validation configuration of the ATMS included three computers; the symbolic computer and two real-time mini computers. The computer in the simulation validation system was configured identically to the FTE workstation configuration of this processor. One mini computer (designated the "control law computer") contained the trajectory controller software and communicated with the symbolic computer using a standard protocol. The communication between this mini computer and the symbolic computer was identical to the communication between the computer and the graphics workstation in the FTE workstation configuration. The other mini computer contained a detailed 6 dof simulation of the aircraft and also contained detailed models of the downlink and uplink telemetry system. The two mini computers communicated in engineering units through FORTRAN named common blocks using a two-port shared memory.

4.3.3 Flight System

The configuration of the ATMS flight system is shown in Figure 7. The flight system was to be used to conduct flight test by executing the flight test plan, monitoring the performance of the aircraft, and controlling the aircraft in flight.

The flight system configuration of the ATMS included three computers; a symbolic computer and two mini computers. The computer in the flight system was configured identically to the FTE workstation and simulation validation system configurations of this computer. One mini control law computer contained the trajectory controller software and communicated with the computer using a standard protocol. The communication between the control law computer and the smaller computer was identical to the communication between the smaller computer and the control law computer in the simulation validation system configuration. A second mini computer (designated the "engineering units computer") was included in the flight system and provided processing required for the uplink and downlink telemetry systems. The communication between

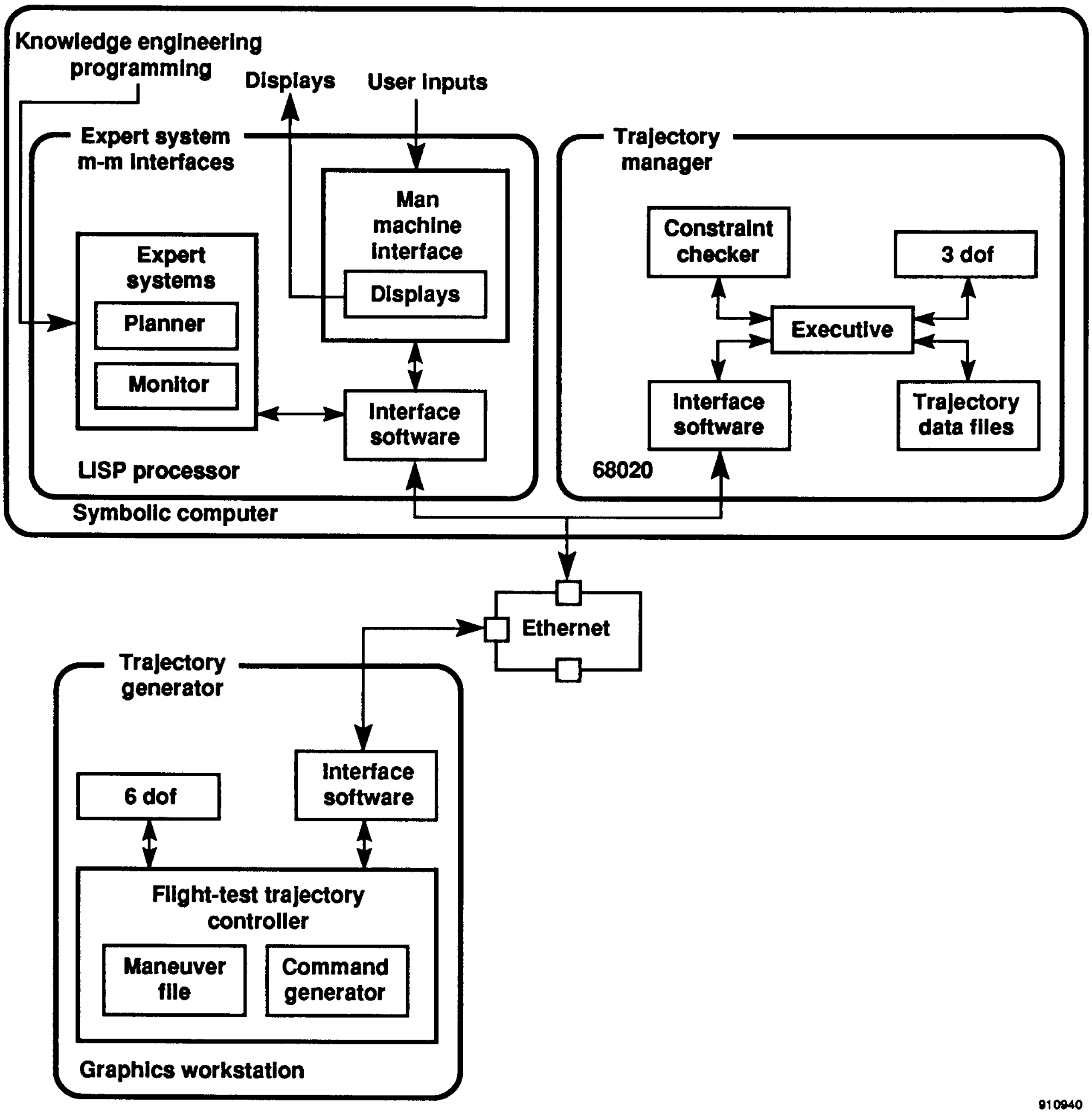

Fig. 5 FTE workstation configuration.

the two mini computers was identical to the communication between the two mini computers in the simulation validation configuration. In the flight system, the simulation model of the aircraft and telemetery systems were to be replaced with actual systems.

5 THE EVOLUTION OF TEST_PLAN FROM THE AUTOMATED FLIGHT-TEST MANAGEMENT SYSTEM

The first version of the ATMS was used to develop the rapid prototyping facility for flight research in advanced systems concepts [2,10]. This rapid prototyping facility was intended to allow easy transition from concept to simulation then to flight. Not only was ATMS the first system to be used in this facility, it was the first system to benefit from the capabilities provided by this facility.

As originally conceived, ATMS was to have combined several concepts into a single system that would allow planning, simulation, execution, and monitoring of research test flights. But this was unachievable for several reasons. The most apparent problem was the inadequacies of the symbolic processors and the expert system development language when applied to real-time tasks. Without this

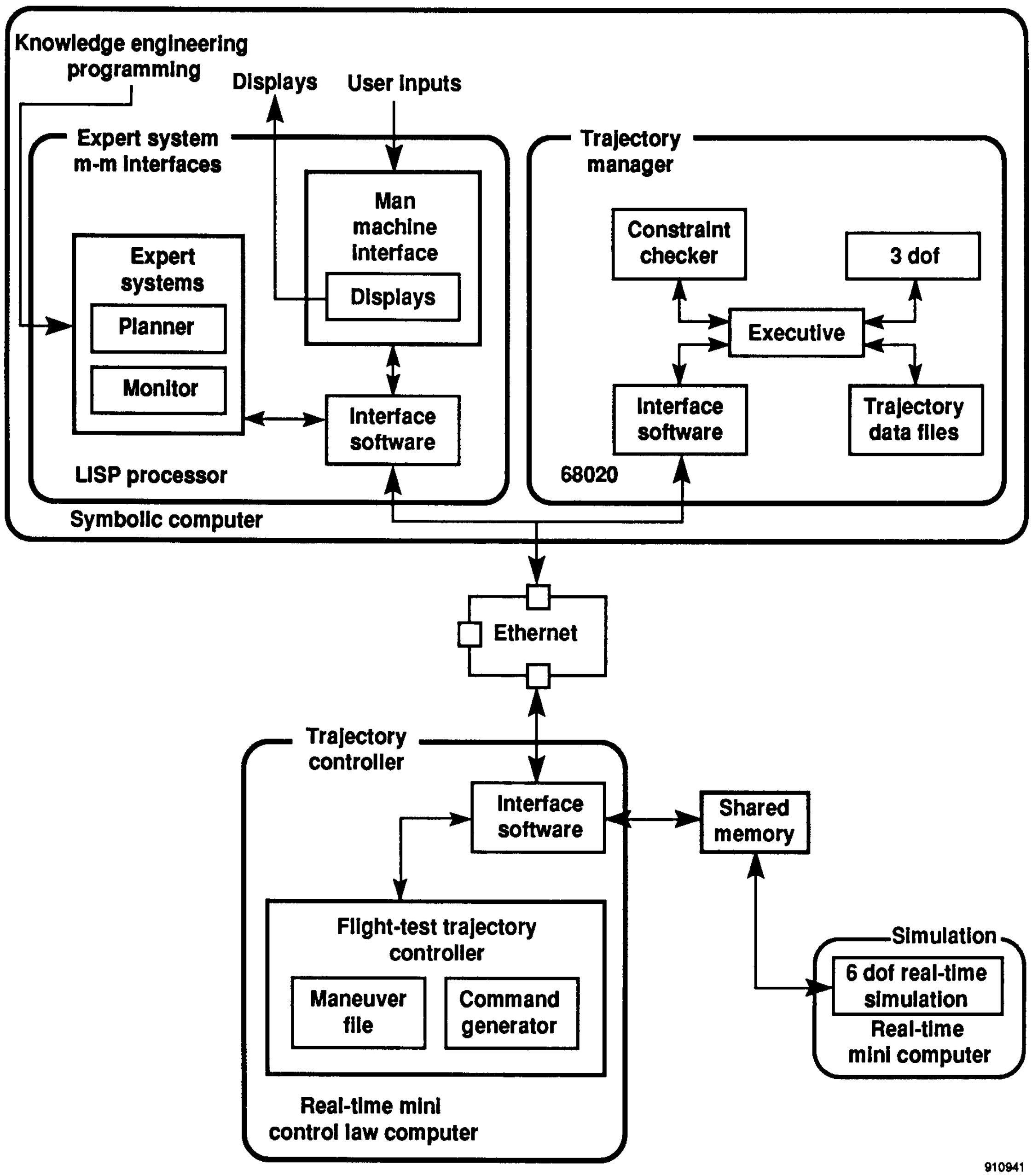

Fig. 6 Simulation validation system configuration.

facility these problems might not have been detected until much later in the development program.

The problem of computers and expert system development languages was addressed by re-implementing the expert systems using CLIPS ('C' Language Production System), converting from LISP to 'C,' using X-windows for the graphical user interface, and re-hosting the system on standard numeric workstations.

Finally, experience in the rapid prototyping showed the difficulties inherent in a system as ambititious as ATMS. Instead of a single system to manage all aspects of planning, simulation, execution, and monitoring, we decided to develop several separate but compatible systems. Thus, the rapid prototyping facility allowed realistic decisions to be made about the viability of the ATMS concept.

TEST_PLAN is the result of the decision to expand the portion of ATMS that provided the FTE with a planning tool. This system, while the development was under government auspices, was called the "flight test engineer's workstation" [3] and TEST_PLAN when extended and commercialized by G & C Systems Inc. (G & C Systems Inc., San Juan Capistrano, CA).

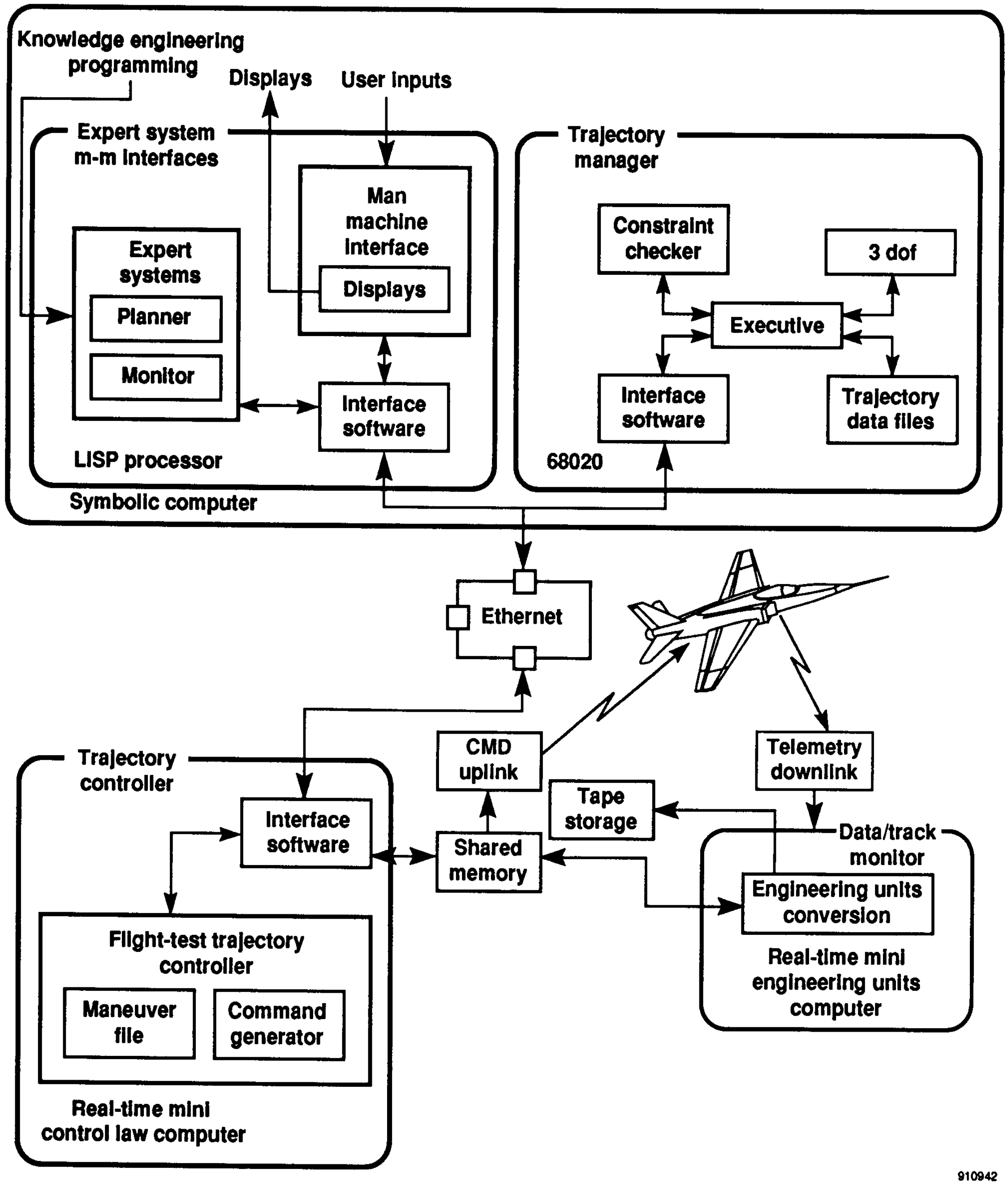

Fig. 7 Flight system configuration.

6 TEST_PLAN

TEST_PLAN is a computer program designed to run on standard graphics workstations (under either the UNIX® or VMS operating systems) as an aid to FTEs in planning and executing flight-test programs. TEST_PLAN allows the FTE to organize and file extensive amounts of planning data while satisfying planning requirements on a flight-by-flight basis using aircraft and flight specific information about instrumentation, telemetry, range, center-of-gravity, airborne and ground support, aerodynamic configuration, system configuration, and payload.

6.1 TEST_PLAN Components

The primary components of TEST_PLAN (shown in Fig. 8) include:

1. A planning facility with over 1000 flight-test planning procedures,

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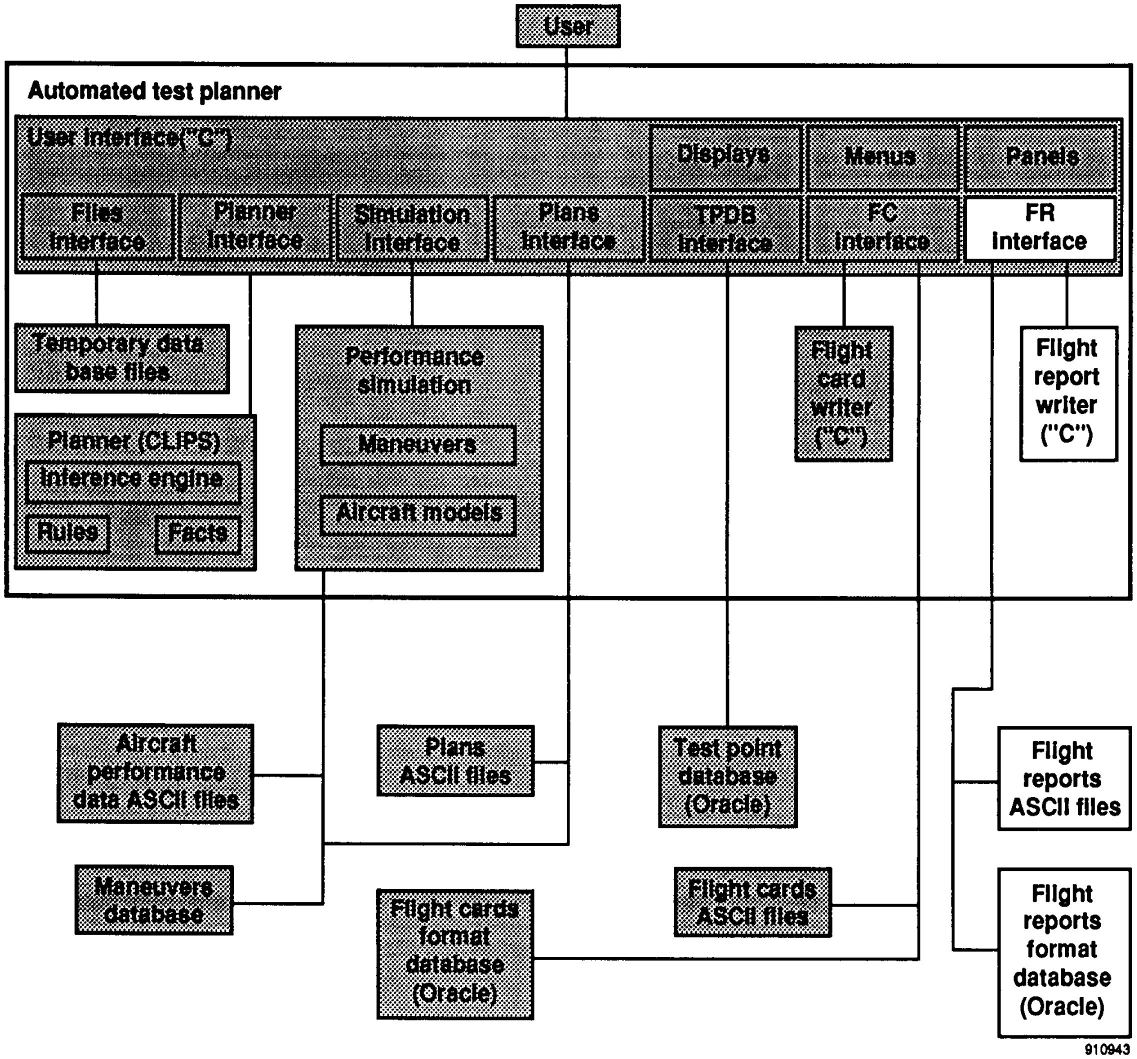

Fig. 8 TEST_PLAN system architecture.

2. an extensive graphical user interface (GUI),
3. an interface with a relational database management system (RDBMS),
4. an aircraft performance simulation facility,
5. a flight card generation facility, and
6. expert system based planning aids.

In the following sections, we will discuss these components of TEST_PLAN.

6.1.1 Planning Facility

The heart of TEST_PLAN [11] is a planning facility consisting of a planning matrix and over 1000 planning procedures. The planning matrix consists of flight-test maneuvers and contingency maneuvers organized by flights for each individual aircraft in a flight-test program. The planning matrix is displayed in an easy to use format (Fig. 9).

The automated planning procedures allow the FTE to plan flight-test programs by defining maneuvers and filling out the planning matrix. The basic philosophy implemented in the TEST_PLAN planning facility (Fig. 10) features the creation of a centralized database of test points in an RDBMS which must be satisfied in the flight-test program; the creation of multiple flight-test plans consisting of test points assigned to flight-test maneuvers, flight-test maneuvers assigned to flights, and flights assigned to blocks of flights for specific flight-test aircraft; and continuous, automated constraint checking between test points, maneuvers, and flights for test point requirements and flight assignments on a flight-by-flight basis.

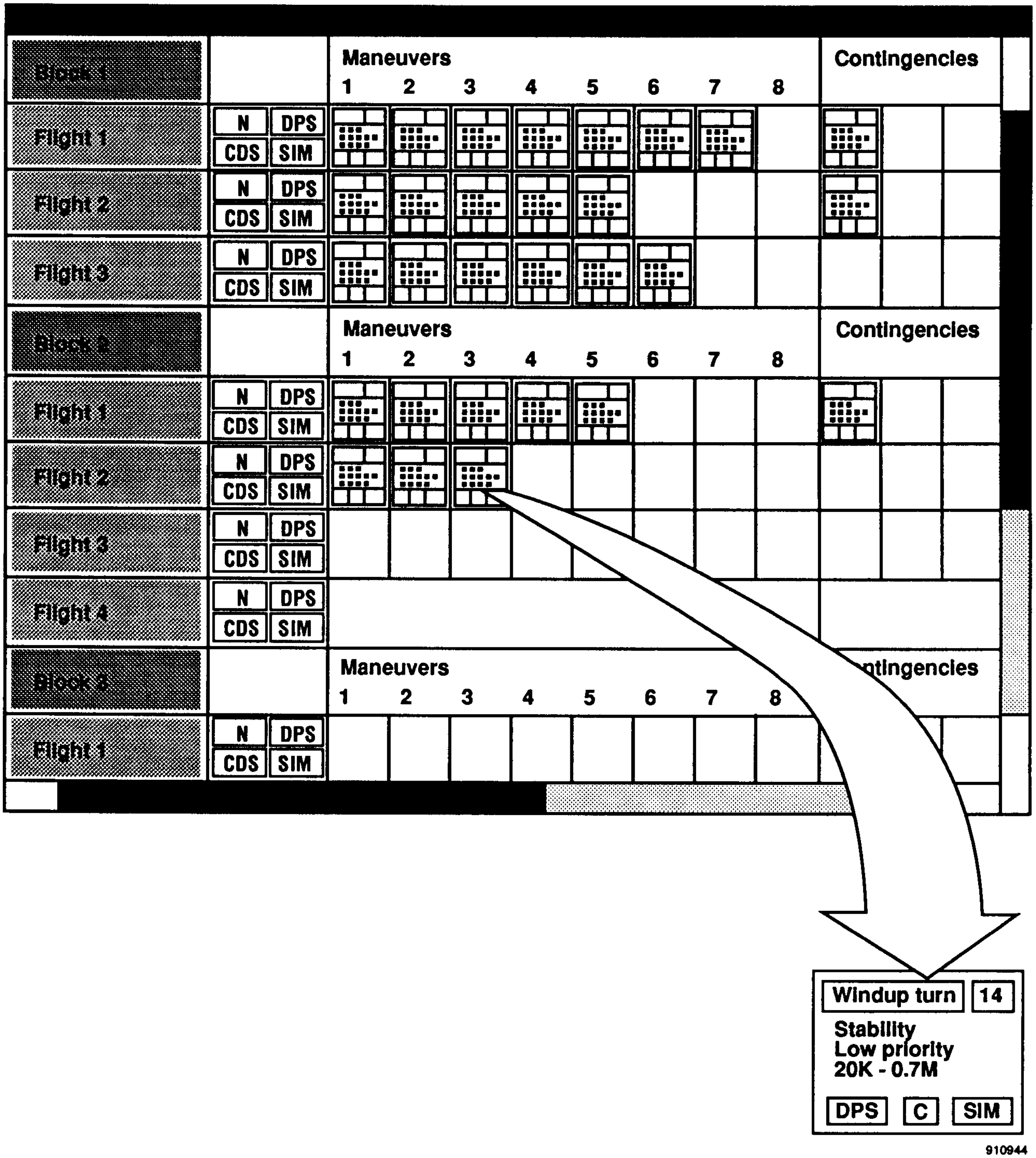

Fig. 9 Planning matrix display.

6.1.2 Graphical User Interface

TEST_PLAN uses graphics extensively. One of its most visible features is a highly developed GUI using X-windows. This interface consists of windows, panels, canvasses, action buttons, and menus. Maximum use of is made of mouse initiated operations. The interface permits the FTE to execute procedures in any order desired—the FTE is not limited to the serial, predefined order of events typically found in a menu-driven application.

Using the TEST_PLAN GUI, the flight-test engineer can perform many tasks which would normally require extensive paper and pencil work. These automated tasks include laying out planning matrices, planning blocks of flights, defining test points, defining flight-test maneuvers, assigning test points to flight-test maneuvers, sequencing flight-test maneuvers to minimize fuel and time required, writing flight cards, and satisfying test point constraints. These test points constraints may be based on instrumentation, aircraft configuration, range (operating area) requirements, telemetry requirements, system configuration,

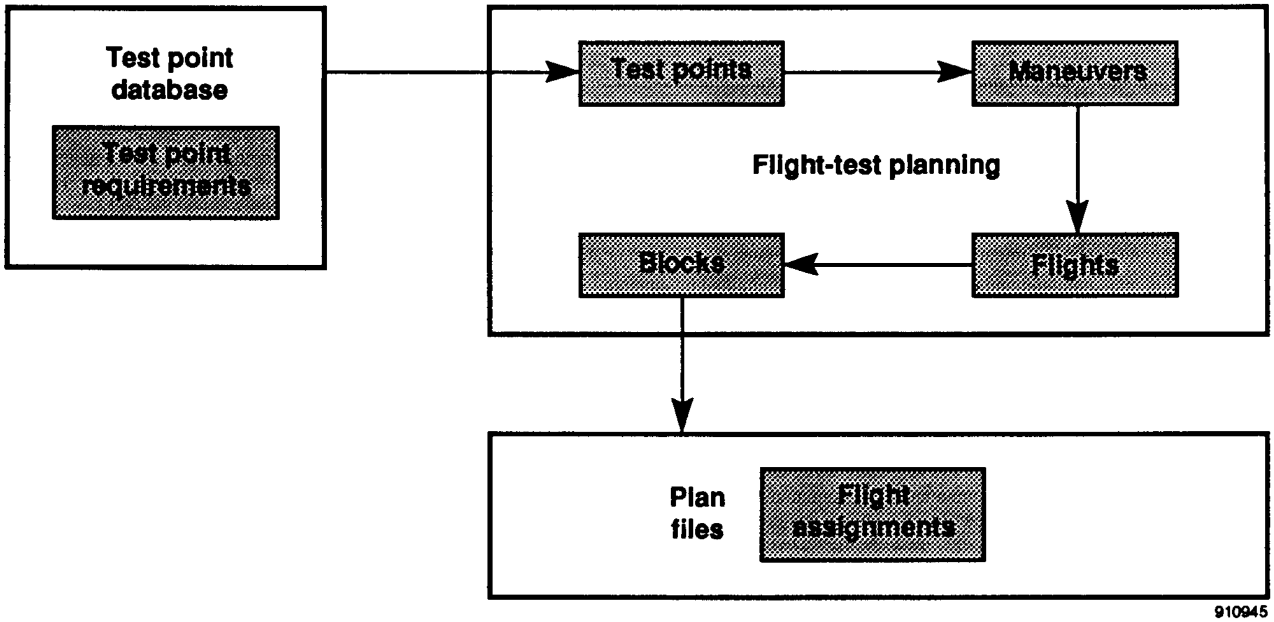

Fig. 10 The TEST_PLAN planning philosophy.

air and ground support requirements, payload, weight and balance requirements, flight limits, trim point conditions, or test point prerequisites.

6.1.3 Relational Database Management System

TEST_PLAN is functionally integrated with the Oracle Relational Database Management System (RDBMS). The RDBMS contains a database of test points for a flight-test program. TEST_PLAN incorporates many procedures which greatly simplify database queries, record additions, modifications and deletions. No special knowledge of the database query language is required because TEST_PLAN provides the user a set of menus, action buttons, and data entry fields as part of the GUI.

6.1.4 Aircraft Performance Simulation

TEST_PLAN contains a 3 dof generic aircraft performance simulation. This simulation requires the user to define an aerodynamic model (of lift and drag coefficients as functions of Mach number and angle of attack) and a propulsion system model (of thrust and fuel flow as functions of altitude and power lever angle).

Using the simulation and this simple definition of the vehicle, TEST_PLAN can compute the trajectory and fuel used in any of 52 preprogrammed maneuvers such as climbs, descents, level accelerations and decelerations, cruise, turns, and dynamic maneuvers. The flight-test engineer also has the capability of building new maneuvers by stringing together combinations of individual maneuvers.

6.1.5 Flight Card Generation Facility

TEST_PLAN provides a flight card generation facility which uses default entries from the flight card database to generate a set of flight cards for a specific flight. The nominal flight card is shown in Figure 11. However, the format can be customized to any desired during the customization portion of an installation of TEST_PLAN.

6.1.6 Expert System Based Planning Aids

TEST_PLAN contains two expert system planning aids; a flight planner and a block planner. The block planner assigns maneuvers (which contain test points) to flights, attempting to minimize the number of flights required to execute the maneuvers within the block while satisfying constraints on instrumentation, configuration, flight limits, flight conditions, prerequisite test points, and range requirements. The flight planner reorders maneuvers within individual flights attempting to satisfy constraints while minimizing fuel and range time used; the flight planner uses fuel and time data obtained from trajectories generated in the performance simulation. An explanation facility is provided.

7 CONCLUDING REMARKS

This report describes the automated flight-test management system and an automated flight test planning system called TEST_PLAN. The evolution of TEST_PLAN from automated flight-test management system is detailed to illustrate the use of rapid prototyping to define system requirements.

Pos	PM	Exp	Alt/Mach	SN 145236	Flight Number FQ - 001
1	1	KE	.2 / ---	START UP, TM CHK (238.2) TAXI (320.2) MIL TO (257.6) / MIL CL Rotate at 175 to theta = 10	
2			.2 / 450 -> 0.8	MIL Climb to 30 MC (310.2)	
3	2	KE	30 / 0.8	WUT to Nz = 6.0 0.5 g/sec	
4		QB	30 / 0.8	ITB	
5			30 / 0.9	ITB	
6	3	PM	30 / 0.7	DESCENT to 10 0.7 M to 300 ITB every 5K	
7	4	KE	10 / 300	ITB	
8			10 / 300	GEAR DN / 1/2 FLAPS YANKEE PATTERN APPROACHES	
9	5	KF	10 / 250	DESCENT to Pattern ILS	
10	6	PM	1.2 / 150	TOUCH & GOS to Landing Fuel Aero breaking to nose fall-through Max breaking with nose on RWY	

910946b

Fig. 11 Nominal flight card format.

8 REFERENCES

[1] Hewett, Marle D., David M. Tartt, Eugene L. Duke, Robert F. Antoniewicz, and Randal W. Brumbaugh, "The Development of an Automated Flight Test Management System for Flight Test Planning and Monitoring," Proceedings of the First International Conference on Industrial and Engineering Applications of Artificial Intelligence and Expert Systems, Tullahoma, TN, June 1–3, 1988, Vol. 1, University of Tennessee, 1988, pp. 324–333.

[2] Duke, Eugene L., Marle D. Hewett, Randal W. Brumbaugh, David D. Tartt, Robert F. Antoniewicz, and Arvind K. Agarwal, "The Use of an Automated Flight Test Management System in the Development of a Rapid-Prototyping Flight Research Facility," 4th Conference on Artificial Intelligence Applications, Long Beach, CA, May 4–6, 1988. (See also NASA TM-100435, 1988.)

[3] Tartt, David D., Marle D. Hewett, Eugene L. Duke, James A. Cooper, and Randal W. Brumbaugh, "The Development of a Flight Test Engineer's Workstation for the Automated Flight Test Management System," Proceedings of the Society of Flight Test Engineers, 20th Annual Symposium, Reno, NV, Sept. 18–21, 1989, pp. 5.2-1 to 5.2-12.

[4] Duke, Eugene L., Michael R. Swann, Einar K. Enevoldson, and Thomas D. Wolf, "Experience with Flight Test Trajectory Guidance," *J. Guidance, Control and Dynamics*, Vol. 6, No. 5, 1983, pp. 393–398.

[5] Duke, Eugene L., Frank P. Jones, and Ralph B. Roncoli, *Development and Flight Test of an Experimental Maneuver Autopilot for a Highly Maneuverable Aircraft*, NASA TP-2618, 1986.

[6] Walker, Robert and Naren Gupta, "Flight Test Trajectory Control Analysis," NASA CR-170935, 1983.

[7] Menon, P.K.A. and R.A. Walker, "Aircraft Flight Test Trajectory Control," ISI Report No. 56, Integrated Systems, Inc., Santa Clara, CA, Oct. 1985. (See also NASA CR-179428, 1988.)

[8] Menon, P.K.A., M.E. Badgett, and R.A. Walker, "Nonlinear Maneuver Autopilot for the F-15 Aircraft," ISI Report No. 71, Integrated Systems, Inc., Santa Clara, CA, Dec. 1985.

[9] Antoniewicz, Robert F., Eugene L. Duke, and P.K.A. Menon, "Flight Test of a Trajectory Controller Using Linearizing Transforms With Measurement Feedback," *AIAA Guidance, Navigation and Control Conference, Part 1*, Portland, OR, AIAA 90-3373, Aug. 1990, pp. 518–532.

[10] Duke, Eugene L., Randal W. Brumbaugh, and James D. Disbrow, "A Rapid Prototyping Facility for Flight Research in Advanced Systems Concepts," *Computer*, May 1989, pp. 61–66.

[11] *Automated Flight Test Planning System: TEST_PLAN User's Guide*, G & C Systems, Inc., 30250 Rancho Viejo Road, San Juan Capistrano, CA 92675, 1991.

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13. ABSTRACT *(Maximum 200 words)*

This paper describes the capabilities and evolution of a flight-test engineer's workstation (called TEST_PLAN) from an automated flight-test management system. The concept and capabilities of the automated flight-test management system are explored and discussed to illustrate the value of advanced system prototyping and evolutionary software development.

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